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Hedgerow and Fencerow Management on Corps of Engineers Projects

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PURPOSE: This technical note is a product of the Ecosystem Management and Restoration Research Program (EMRRP) work unit titled "Improved Methods for Ecosystem-Based Habitat Management at Corps Projects." The objective of the work unit is to provide technology on managing wildlife species and their habitats using ecosystem-based strategies. The emphasis is on methods that improve natural resources for a variety of species rather than single species. This note provides an overview of the characteristics of hedgerows and fencerows that allow them to function as wildlife habitat. It describes structural design, establishment, and management, as well as possible negative impacts caused by their use. Emphasis is placed on using native plant species rather than nonnative species to provide wildlife benefits on Corps lands.

BACKGROUND: Wildlife inhabiting agricultural areas is often limited to those habitats that are not intensively farmed because of terrain or landscape features. This habitat isolation is acutely apparent in the Midwest and Great Plains of North America. Much of this region was undisturbed prairie until the late 19th century, when settlers homesteaded on the plains (Robinson and Bolen 1989). After settlement, habitat for native prairie wildlife was destroyed or greatly reduced through tillage practices, severe overgrazing, and fire suppression (Scifres 1987). Consequently, native herbaceous species diversity and the wildlife dependent on these plants declined, and native prairie wildlife was often restricted to small areas that had been left undisturbed.

To combat wind erosion in the 1930s, the U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS), now the USDA Natural Resources Conservation Service (NRCS), encouraged the establishment of field and farmstead windbreaks to protect open lands (NRCS 1997). Technically, a windbreak can be any structure, either living or nonliving (e.g., railroad ties, rocks, retired farm machinery) that acts as a barrier to wind (Brandle and Hintz 1987, Cook and Cable 1990). Shelterbelts, hedgerows, and fencerows are types of windbreaks composed of live vegetation. Shelterbelts are plantings that consist of four or more rows of trees and shrubs, whereas hedgerows and fencerows usually consist of only one to three rows of trees, shrubs, and vines (NRCS 1997). During the Dust Bowl era, the number of windbreaks increased dramatically on the Great Plains as a result of extensive plantings by the SCS and other agencies. Although the primary objective of windbreaks was the protection of prairie soils, an ancillary benefit was an increase in wildlife habitat. These plantings provided wildlife habitat in open landscapes, especially in intensively farmed areas (Crawford 1945, Yahner 1982, Best and Hill 1983, Forman and Godron 1986), and even permitted range extensions of several species (Bolen and Robinson 1999).

Many shelterbelts were removed during the 1940s because farmers believed they harbored insect pests and competed with crops for water and nutrients. The advent of clean farming and highly mechanized operations resulted in an increase in the average size of cropped fields, which occurred at the expense of hedge- and fencerows and habitat interspersion (Vance 1976, Bolen

and Robinson 1999). Extensive clearing activities associated with irrigation development also eliminated fencerows. The Food Security Act of 1985 (usually referred to as the Farm Bill) was passed to discourage agricultural producers from cultivating erodible soils, and financial incentives were offered to farmers to establish protective vegetative cover on these soils. Thus, new windbreaks were established throughout the Great Plains states.

In this report, hedgerows and fencerows are defined as continuous strips of herbaceous vegetation, shrubs, and/or small trees that occur along man-made fence lines or, in the absence of conventional fencing, are established to serve as barriers (Figure 1). Hedgerows and fencerows have the broader application on Corps of Engineers (Corps) projects, but multi-row shelterbelts and windbreaks have been successfully established as wildlife habitat on projects in several Midwestern and Northern states. Although windbreaks are more common in the Midwest and Great Plains, many of their characteristics and most of the management recommendations are applicable to other geographic regions.

Figure 1. Hedgerow established in an open field at Lake Shelbyville, Illinois

HEDGEROW AND FENCEROW VALUE

Land Management Benefits. Windbreaks are usually established to protect nearby leeward areas from high winds. These plantings can be used to reduce soil erosion, protect crops and forage plants, manage snow, improve irrigation efficiency, protect structures and livestock, screen undesirable views, reduce noise, and provide wood products (NRCS 1997). They increase crop production by reducing soil erosion, causing variations in soil moisture, and modifying microclimates (Frank, Harris, and Willis 1976; Goldsmith 1976; Rosenburg 1976; Norelius 1984). Hedgerows have been especially effective in reducing wind erosion when used in conjunction with other appropriate management practices. Hedgerows on hilly terrain inhibit soil erosion, protect soil nutrients, and improve water quality and flow rate of adjacent streams (Forman and Godron 1986). Contour hedgerows promote the formation of terraces as sediment accumulates on the uphill sides; such deposits enhance soil moisture (Edminster 1938). Sodded borders that extend 1.8 m (6 ft) beyond the shrub dripline prevent umbrella-effect runoff from causing washouts (Woehler and Dumke 1982). Hedgerows also provide privacy and sociological benefits by screening nearby structures and delineating landscape features (Moen 1983).

Wildlife Value. The diversity of wildlife attracted to well-managed hedgerows with a variety of trees and shrubs contributes to landscape appeal. The woody vegetation provides many species with food, cover, and spatial components that are otherwise absent in open landscapes (Stormer and Valentine 1981). Many animals receive adequate moisture from the succulent fruits, leaves, and twigs and often obtain additional water from precipitation that collects on the vegetation. The presence of dead or decaying trees benefits many avian species by providing nest cavities,

foraging sites, and perches for singing or foraging (Hinsley and Bellamy 2000). Winter cover is an important habitat component provided by hedge- and fencerows, as animals using these plantings are able to conserve energy more efficiently and thus increase their survival prospects; animals not only benefit from the protection but may also obtain food in proximity to cover (Petrides 1942; Barnes, Keyser, and Linder 1989). Plantings on open lands may function as wildlife corridors (travel lanes) for both local and larger-scale movements (Range 1984, Forman and Godron 1986). Hedgerows facilitate access to resources or habitat that might otherwise be too risky or remote for use or colonization (Dmowski and Kozakiewicz 1990, Clergeau and Burel 1997). However, such corridors may increase predation and act as population "traps" or "sinks" for some species of nesting birds (Fischer et al. 1999).

The interspersion of wildlife habitat components is a major contribution of hedgerows. The increased edge associated with these plantings benefits upland game birds that favor habitats with a high degree of interspersion, such as the northern bobwhite (*Colinus virginianus*) (Roseberry and Klimstra 1984, Kuvlesky 1990) and ring-necked pheasant (*Phasianus colchicus*) (Taylor, Wolfe, and Baxter 1978). Hedgerows provide habitat interspersion in both horizontal and vertical dimensions. Increased vegetative complexity in the vertical dimension permits coexisting bird species to partition space more efficiently and thus increase avian species diversity (Yahner 1982). Best and Hill (1983) speculated that the high avian species diversity within fencerows on Iowa farmlands was a consequence of the extensive structural diversity created by a variety of trees and shrubs. A British study (Hinsley and Bellamy 2000) found that the two most important factors positively associated with species richness and abundance of breeding birds in hedgerows are hedge size and the presence and abundance of trees that provide cover and vegetative and structural complexity. However, large hedges are not suited to all species, as birds tend to prefer vegetative types that most closely resemble their usual non-hedgerow breeding habitat. Hinsley and Bellamy (2000) also found that increased structural complexity of a hedgerow might reduce the incidence of predation and thus provide additional protection for nesting birds. The habitat requirements of animals that commonly inhabit hedgerows are reviewed below.

- ***Upland game birds.*** Declines in upland game bird populations in the Midwest have been associated with the loss of shelterbelts and hedgerows. These were essentially the only sources of brooding and winter cover for resident ring-necked pheasants in Nebraska croplands (Taylor, Wolfe, and Baxter 1978). In Illinois, Roseberry and Klimstra (1984) attributed the long-term decline in northern bobwhite populations to modern agricultural practices, such as clean farming, large cropping units, and monocultural crops. The many miles of fencerows and hedgerows that were removed in the 1940s eliminated critical nesting and escape cover.

  Studies have shown that fence- and hedgerows with scattered trees and shrubs are important northern bobwhite habitats in agricultural areas (Errington and Hamerstrom 1936, Kabat and Thompson 1963, Vance 1976). Missouri croplands with adequate supplies of brushy hedge- and fencerows produced substantially more bobwhite than similar areas lacking this cover (Crawford 1945). Woody hedgerows constituted the principal form of winter cover for bobwhite on Wisconsin farmlands (Kabat and Thompson 1963), and fencerows containing grapevines mixed with other vegetation provided highly superior winter cover for bobwhite in Iowa and Wisconsin studies (Errington and Hamerstrom 1936).

Hedge- and fencerows offer seasonal habitat for ring-necked pheasants (Figure 2). For example, fencerows with grass and weeds provided nesting and brood cover for pheasants in Montana (Weigand and Janson 1976), and nests surveyed in a fencerow study in Michigan were found exclusively in grassy fencerows (Shalaway 1985). Petrides (1942) concluded that wide hedgerows provided preferred nesting sites for pheasants while decreasing the likelihood of predation. Hedgerows serve as travel corridors that enable birds to move unobtrusively between areas (Petrides 1942, Weigand and Janson 1976). Low, dense cover is preferred for winter roosting (Trippensee 1948). Pheasants are intolerant of deep, persistent snow, and flocks may be decimated in areas of poor cover (Weigand and Janson 1976). Ideal winter hedgerow cover catches snow on the north and west sides but retains a relatively snow-free center; wide fencerows composed of small trees and shrubs usually satisfy this requirement (Farris, Klonglan, and Nomsen 1977).

Figure 2. Hedgerows and fencerows provide important cover for ring-necked pheasants (*Phasianus colchicus*) *(photo courtesy of Robert J. Martin)*

- ***Nongame birds.*** Hedgerows provide habitat for many nongame birds. In grasslands or agricultural lands, the addition of woody vegetation increases ecosystem complexity and results in the formation of new habitats that become occupied by species that may have previously been absent. Best and Hill (1983) evaluated avian species diversity in three fencerow habitat types in Iowa and found that fencerows consisting of continuous trees and shrubs had the greatest structural diversity and, thus, the greatest bird species diversity. These fencerows harbored as many as 36 bird species per 10 km (6.2 miles), whereas fencerows lacking woody cover had only 9 species per 10 km. Along continuous tree-shrub fencerows, 48 avian species were recorded, with 38 species in scattered tree-shrub fencerows and 12 species in herbaceous fencerows.

  The structural diversity and vegetative complexity present in a well-planned hedgerow provide an abundance of food and cover. The ground stratum is important to insectivorous birds because of the abundance of insects within this layer (Yahner 1982). Older trees and snags are sources of insect prey for tree-gleaning birds (Bohn et al. 1980, Yahner 1983a), and fruits produced by woody plants support frugivorous species (Crawford 1945, Bohn et al. 1980, Yahner 1982). The hard seeds of herbaceous vegetation are found in the ground stratum, which attracts seed-eating species (Crawford 1945).

  Hedgerows and fencerows provide nest sites for nongame birds (Figure 3). High densities of nesting birds have been found in linear agricultural habitats such as fencerows and roadside ditches (Basore, Best, and Wooley 1986; Bryan and Best 1994). Morgan and Gates (1982) believed that birds inhabiting hedgerows had higher nesting success than species nesting along hedgerow-forest edges. Best and Hill (1983) suggested that fencerows

characterized by continuous tree and shrub cover provided critical nesting habitat on their intensively farmed Iowa study area.

Hedgerows offer escape and protective cover to nongame birds during weather extremes (Morgan and Gates 1982, Best and Hill 1983), thus enhancing the overwinter survival of birds using them (Brandle and Hintz 1987, Yahner 1983a). Petrides (1942) in New York and Emmerich and Vohs (1982) in South Dakota reported high winter bird densities in the hedgerows on their study sites. Wintering songbirds use deciduous hedgerows, even those lacking food reserves, as protection from the wind (Woehler and Dumke 1982). Fencerows with larger trees can also provide roost sites and hunting perches for raptors in open areas.

Figure 3. Hedgerows provide food and cover for many nongame species, such as the brown thrasher (*Toxostoma rufum*)

- ***Mammals.*** Shelterbelts and hedgerows function as important habitats for small mammals. Approximately 20 mammalian species were identified through pellet analysis of raptors using shelterbelts in South Dakota (Norelius 1984). The most commonly reported species were the eastern cottontail (*Sylvilagus floridanus*), thirteen-lined ground squirrel (*Citellus tridecemlineatus*), plains pocket gopher (*Geomys bursarius*), black-tailed jackrabbit (*Lepus townsendii*), mice (*Peromyscus* spp.), and voles (*Microtus* spp.). Petrides (1942) reported that white-footed mice (*P. leucopus*) were common in hedgerows. Species richness tends to vary according to habitat complexity. Large multi-rowed shelterbelts, comprised of a variety of trees and shrubs with an abundance of woody debris on the ground, are likely to have greater small-mammal species richness than hedgerows or fencerows (Yahner 1983b). Yahner (1983b) indicated that white-footed mice and southern red-backed voles (*Clethrionomys gapperi*) were attracted to woodlands, whereas meadow voles (*M. pennsylvanicus*) preferred herbaceous habitats; shrews (*Sorex cinereus, Blarina brevicauda*) were intermediate with regard to their dependence on shelterbelts. Rodent damage to windbreaks and crops is usually negligible, as the species inhabiting these plantings are not traditionally those that damage woody vegetation (Yahner 1983b; Barnes, Keyser, and Linder 1989).

  Cottontails (*Sylvilagus* spp.) are the most common small game mammals inhabiting windbreaks in agricultural areas. Morgan and Gates (1983) attributed the extensive use of hedgerows by cottontails in Maryland to their preference for dense, horizontal, woody cover close to the ground. The shrub-dominated habitats of hedge- and fencerows furnish the eastern cottontail with food, shelter, travel corridors, and escape cover (Allen 1984), which is of critical importance during winter (Petrides 1942). Hedgerows provide cottontails with an abundance of food because many of the woody species that furnish escape cover are also palatable (Haugen 1942; Smith 1950; Barnes, Keyser, and Linder 1989). Hedgerows are attractive to burrowing mammals, whose excavations are frequently used

by cottontails for nurseries, escape cover, and shelter from inclement weather; woodchuck (*Marmota monax*) burrows, in particular, are used (Allen 1939).

Deer (*Odocoileus* spp.) have large home ranges that encompass a variety of habitat types. Although windbreaks and hedgerows are small relative to home range size, deer on the eastern, central, and northern Great Plains use large shelterbelts (Severson 1981, Menzel 1984, Peterson 1984). The much smaller hedgerows are probably used only for browsing when deer occupy the surrounding habitat.

Hedgerows usually harbor only a few mammalian predators, primarily because the area of plantings is small relative to the spatial requirements of most predatory species. Smaller predators, which are the most common carnivores attracted to hedgerows, use them for foraging or denning. Forman and Godron (1986) found that striped skunks (*Mephitis mephitis*) were common around hedgerows, where they fed on small mammals that were more abundant than in the surrounding cultivated fields. Shalaway (1985) reported that raccoons (*Procyon lotor*), skunks, and weasels (*Mustela* spp.) fed and traveled along hedgerows and fencerows in Michigan. Petrides (1942) found that red fox (*Vulpes fulva*) tracks were common along hedgerows on New York farms during spring, and Forman and Godron (1986) reported fox denning activity in hedgerows isolated from human activity. Foxes and coyotes are often attracted to hedgerows when trees and shrubs are producing fruit, as these items are readily consumed when available. Opossums (*Didelphis virginiana*) will also use hedgerows.

- ***Herpetofauna.*** Although little information is available on amphibian and reptile use of hedgerows, these plantings probably provide microhabitats for a number of species that depend on woody vegetation for structure and shade. Green anoles (*Anolis carolinensis*) and fence lizards (*Sceloporus* spp.) are especially attracted to hedgerows and fencerows; rat snakes (*Elaphe obsoleta*) have been reported from South Dakota shelterbelts (Norelius 1984).

HEDGEROW DESIGN: Carefully designed and well-managed hedgerows and fencerows can provide long-term benefits. Planning and design should be viewed on two scales of resolution: a landscape-scale and a fine (ground)-scale. Designs developed from a landscape perspective allow managers to determine how design and placement will affect management operations as well as wildlife resources. The fine-scale perspective enables the development of a design that fulfills specific needs.

Site Selection. Although hedgerows and fencerows traditionally delineated field boundaries in agricultural operations, these plantings may be established in numerous locations to create or improve wildlife habitat. Open rangelands and farmlands are excellent sites for hedgerow placement (Jackson 1969, Range 1984). Since hedgerows are primarily long and linear, their presence on prairies or in areas of intensive cultivation significantly increases habitat interspersion. However, the planting of hedgerows and fencerows should not be restricted to agricultural sites. Plantings can be established on landscape areas, idle areas, and other expanses of open land lacking in vegetative and structural diversity. Hedgerows placed across large open areas may establish a network of travel corridors that connects isolated pockets of habitat, and hedgerows located along ditchbanks help stabilize the soil. Hedgerows and fencerows may serve as corridors across manicured grounds (or areas where land-use patterns have minimal wildlife value) and enable wildlife to access suitable adjacent habitats (Range 1984). Sites with complimentary cover, such as herbaceous vegetation or unmowed grassy areas, amplify the wildlife value of hedge- and fencerows.

If planted with noninvasive ornamental species, hedgerows and fencerows can be used to landscape for aesthetic purposes. These plantings are effective in screening work areas, maintenance compounds, and parking lots. Fencerows along trails and walkways offer pedestrian containment and lend protection to sensitive natural areas or other landscape features adversely impacted by foot travel. Hedge- and fencerows may be used to delineate project boundaries or to create permanent, attractive, and effective alternatives to snow fencing along roadways. The use of nonnative species should be kept to a minimum, and exotic plants that may escape and compete with native vegetation should never be used.

Design. It is important to adhere to an effective design, as improperly designed hedgerows may experience structural damage from gusting winds and drifting snow (Schoten 1988). Factors to consider when designing a hedge- or fencerow are width, exposure, and species composition. The width of the planting affects nesting success, diversity of wildlife species, and effectiveness as winter cover. In general, a wider fencerow or hedgerow increases the potential for heterogeneity of both flora and fauna. Plantings that consist of only one or two rows of shrubs generally lack species and structural diversity. Wider fencerows decrease the probability of nest detection by predators (Shalaway 1985) (Figure 4).

Figure 4. Multi-row windbreaks (L) or fencerows are more desirable for wildlife than those consisting of only a few rows (R)

Dumke (1982) and Payne and Copes (1986) advocated 7.6-m (25-ft)-wide hedgerows composed of one row of shrubs and two rows of conifers. A minimum of four rows was recommended if shrubs are used exclusively (Payne and Copes 1986). Four rows are considered optimum in situations where adjacent lands are cropped annually (Woehler and Dumke 1982). Doolen (1998) suggested planting 15-m (50-ft)-wide hedgerows if space is available. This size allows for a 6-m (20-ft)-wide center strip of trees to serve as a travel lane, a 1.5-m (5-ft)-wide shrub lane on each side of the center strip, and a 3-m (10-ft) strip of warm-season grass outside the shrub strips.

In northern regions, the combination of shrubs and conifers provides effective winter cover if two or three rows of shrubs are planted on the outside to catch snow (Farris, Klonglan, and Nomsen 1977). This design should provide an area of cover sufficiently large to catch snow on

the north and west sides while leaving the interior relatively snow free. Shrubs are usually planted on either the inside or lee side of the conifer rows (Woehler and Dumke 1982). In mid-winter, both game birds and songbirds congregate within the canopies of brushy fencerows with southerly or easterly exposures.

For shelterbelt plantings, Schoten (1988) recommended row spacing of 20 m (66 ft) for trees with 7-m (23-ft) intervals between trees within rows. Woehler and Dumke (1982) recommended 1.8-m (6-ft) spacing for both shrub rows and seedlings within rows. The latter spacing allows plenty of room for full shrub development, requires fewer seedlings to effectively cover a large area, and eliminates the practice of planting multiple stems per hole as shrub selection criteria usually favor species with multiple-stem growth forms. Trees planted too close together often receive insufficient nutrients, water, and sunlight, which results in weakened plants that are more susceptible to disease and predation than healthy specimens spaced at correct intervals.

ESTABLISHMENT

Site Preparation. Site preparation may be the most important factor in assuring early survival of trees and shrubs (Schoten 1988). To conserve soil moisture, sites should remain fallow for at least a year before planting. During this period, a post-emergent herbicide should be applied to the site to control herbaceous vegetation, preferably at the beginning of the growing season (early spring) one year before the projected planting date (SCS 1980). To eliminate herbaceous plants that survive the post-emergent herbicide, a pre-emergent herbicide should be applied shortly after initial treatment and during summer if forbs and grasses appear (Schoten 1988). Controlling herbaceous vegetation reduces competition for water, nutrients, and sunlight, thus enhancing young tree and shrub survival and encouraging more rapid growth.

Soil texture is an important factor in preparing a hedgerow site. Schoten (1988) recommended cultivating (tilling) heavy soils during the fall prior to spring planting, so that winter freezing and thawing can reduce large clods associated with heavy soil tilling. Tilling heavy soils during spring may also compact soils, further complicating planting operations. Finely textured soils should be cultivated in spring to minimize the risks of erosion. If the soil is highly erodible, site preparation may be limited to the rows to be planted, or even to the site of each tree or shrub. Site preparation on croplands, pastures, and hayfields varies somewhat with the kind of crop to be planted.

Site Layout. Based on the hedgerow design, the location of each row and individual plants within rows should be established on the planting site. Items needed to install the design are a 100-m (330-ft) steel tape to lay out the rows and wooden stakes or metal pins with colored flagging to mark the rows. The following instructions for laying out a hedgerow have been modified from Schoten's (1988) recommendations for a shelterbelt.

Using the tape, establish the boundaries (ends) of the two outside rows and mark the corners. Starting at one corner, carefully measure the spacing between rows (20 m, 66 ft) and mark the precise origin of each row. Establish the terminal end of each row by stretching the tape from the row origin to the opposite boundary (line between the terminal ends of the outside rows). If the

row is straight, the terminal end of the tape will intersect the opposite boundary very near the predetermined row length.

After rows have been established, determine tree and shrub locations. Stretch the measuring tape the length of each row and mark the planting site of trees at 7-m (23-ft) intervals (Schoten 1988) and of shrubs at 1.8-m (6-ft) intervals (Woehler and Dumke 1982). Stagger trees in alternate rows so that each tree is placed halfway (3.5 m (11.5 ft)) between two trees in the adjacent rows. After marking the planting sites, calculate the needed number of plants by dividing the length of each row by the tree or shrub spacing within the row. Of that number, determine how many plants of each species to order.

Plant Selection. The selection of woody species that produce both food and cover maximizes the benefit of a prospective planting for wildlife. The species planted should be those most preferred by wildlife. A selection of native woody plants suitable for hedge- and fencerows is given in Table 1. It is desirable to purchase plants from regional nurseries because of the variation in ecological adaptations of plants to different geographic regions of the country. Information regarding regional species adaptability can be obtained from agricultural extension agents, NRCS field offices, and commercial nurseries.

In general, shrubs used in hedgerow and fencerow plantings should have the following characteristics (Woehler and Dumke 1982):

- Multiple stems that provide horizontal cover near ground level and heavy, arching branches.
- Minimal aggressive spreading via seeds or rootstocks.
- Productive span of at least 25 years.
- Capacity to grow well on mesic sites of average fertility.
- Winter hardiness of plants and buds in regions subject to harsh winters. Shrubs that resist bud-break at the first sign of mild weather would be advantageous.
- Ready availability of planting stock from state or private nurseries.

Planting an assortment of species rather than stands of a single species offers several advantages. The most obvious is the creation or augmentation of diversity. By selecting species that fruit at different times of the year, food production can be sustained almost continually throughout the growing season (Woehler and Dumke 1982). If one species fails to produce fruits or seeds in a given year, another species may provide an adequate crop and thus avert a mast failure. The fruit retention characteristics of a species are important considerations, as fruits that persist into winter provide a valuable food resource in areas subject to severe winters. Petrides (1942) considered the scarcity of available food during late winter to be the factor limiting the carrying capacity of hedgerows. Mixed plantings may also incur fewer losses during outbreaks of diseases, insect pests, or periods of climatic extremes (Woehler and Dumke 1982).

Table 1
Selected Native Woody Plants Valuable to Wildlife and Suitable for Use in Hedge- and Fencerows (Edminster 1939, Gill and Healy 1974, Woehler and Dumke 1982)

Common Name	Scientific Name	Common Name	Scientific Name
Shrubs		**Shrubs (cont.)**	
American elder	*Sambucus canadensis*	Highbush blueberry	*Vaccinium corymbosum*
Scarlet elder	*S. pubens*	Witch-hazel	*Hamamelis virginiana*
Silky dogwood	*Cornus amomum*	Wild plum	*Prunus americana*
Gray dogwood	*C. racemosa*	Brambles[1]	*Rubus* spp.
Red-Osier dogwood	*C. stolonifera*	Common chokecherry[2]	*Prunus virginiana*
Flowering dogwood	*C. florida*	**Vines**	
American hazel	*Corylus americana*	Bittersweet	*Celastrus scandens*
Thornapple, hawthorn	*Crataegus* spp.	Virginia creeper	*Parthenocissus quinquefolia*
Ninebark	*Physocarpus opulifolius*	Wild grape	*Vitis* spp.
Crabapple	*Malus* spp.	Trumpet vine	*Campsis radicans*
Coralberry	*Symphoricarpos orbiculatus*	**Trees**	
Buffaloberry	*Shepherdia argentea*	Oaks	*Quercus* spp.
Nannyberry	*Viburnum lentago*	Black cherry[2]	*Prunus serotina*
Blackhaw	*V. prunifolium*	Red mulberry	*Morus rubra*
Highbush cranberry	*V. trilobum*	Persimmon	*Diospyros virginiana*
Mapleleaf viburnum	*V. acerifolium*	Walnut	*Juglans* spp.
Arrowwood viburnum	*V. recognitum*	Hickory	*Carya* spp.
Serviceberry	*Amelanchier* spp.	Maples	*Acer* spp.
Black chokeberry	*Aronia melanocarpa*	White spruce	*Picea glauca*
Red chokeberry	*A. rubra*	Blue spruce	*P. pungens*
Staghorn sumac	*Rhus typhina*	Red cedar	*Juniperus virginiana*
Smooth sumac	*R. glabra*	White cedar	*Chamaecyparis thyoides*

[1]Blackberries, raspberries, dewberries.
[2]Potentially toxic to livestock.

Other factors to consider in plant selection are the potential toxicity of selected species and the use of exotic species. The toxicity of selected species must be evaluated for sites bordering pastures or areas anticipating a high level of browsing, as consumption of some plants can be lethal to herbivores. For example, 0.11 kg (0.25 lb) of chokecherry (*Prunus virginiana*) leaves can be fatal to sheep if eaten in one feeding (Johnson and Nichols 1982). The use of exotic species, such as multiflora rose (*Rosa multiflora*) and autumn olive (*Eleagnus umbellata*), is not recommended because of their tendency to spread and replace native plants. Many exotics have been relegated to a nuisance or noxious weed status in some regions of the United States.

Plant adaptations to soil conditions of the planting site should be ascertained before selecting and ordering plants from the nursery. Site evaluation should provide information on soil texture, pH, and water-holding capacity. For example, most pines (*Pinus* spp.) are adapted to sandy soils (Fowells 1966, Schoten 1988) and would probably not survive if planted on deep clay loams or poorly drained sites. Conversely, black cottonwood (*Populus trichocarpa*) and quaking aspen (*P. tremuloides*) are unlikely to grow vigorously in shallow, well-drained soils because they are adapted to rich, humic soils with high water content (Fowells 1966). Some species are quite elastic in regard to their soil requirements and grow well under a variety of soil conditions.

Plant Procurement. Trees and shrubs should be ordered from a reputable nursery located in the same region as the hedgerow site. Regionally raised nursery stock is acclimated to environmental conditions at the planting site and is, therefore, likely to experience more rapid growth and higher survival rates. Plants can be ordered in various conditions, depending on desired plant age and economic constraints (SCS 1980). Nursery stock can be expensive, and the labor required for planting may add significantly to the cost of a hedge- and fencerow program. However, the ability to control species composition, structural and species diversity, and nuisance species problems may justify initial expenditures and reduce future maintenance costs.

Seedlings or transplant stock should be considered if young trees are needed when funds are limited. Seedlings are grown in nursery beds for 1 to 3 years and then uprooted for planting. Transplant, or bare-root, stock are plants removed from nursery beds after 1 to 2 years, transplanted to other beds for 2 to 3 years, and then moved to the final planting site. Container stock is sown directly into containers of various sizes, grown for several years, and then delivered ready for planting. Because the root systems are protected, container stock usually experiences better survival than bare-root plants but is more expensive. If older or larger trees are desired for planting, potted plants or balled and burlapped stock may be ordered. Survival is generally excellent because these plants are well-established before transplantation. However, older trees and shrubs are expensive, and the cost of a number of hedgerows with older plants would likely be prohibitive.

To maximize survival, nursery stock should be planted as soon as possible after delivery. When delivered, bundles of shrubs should be opened and inspected for damage and moisture content. If the packing around the roots is dry, it should be watered and permitted to re-dry. If planting cannot be accomplished within 1 week, the bundles should be repacked and stored for up to 4 weeks in a cooler or refrigerator at 1.1 to 4.4 °C (34 to 40 °F) (Woehler and Dumke 1982). To prevent desiccation, bundles should be examined during the storage period. Schoten (1988) advised placing bare-root stock in cold storage at about 1.7 °C (35 °F) if planting is to be delayed for a significant length of time. If facilities for cold storage are unavailable, individual plants should be placed at a 45-deg angle in a trench dug in a shady place, and the roots should be covered with soil (SCS 1980). An alternative storage method is heeling-in, or placing the individual seedlings in a trench and packing the soil around the roots. However, heeling-in depends upon the ambient outdoor temperature, which may warm sufficiently to stimulate growth. Locating the trench in shade will prolong dormancy; once dormancy is broken, shrubs should be planted immediately.

Planting Methods. Trees and shrubs may be planted in fall or spring, but it is critical that planting take place while seedlings are dormant (Schoten 1988). It is usually advantageous to plant in early spring before bud initiation, since spring rains provide soil moisture conducive to rapid initial growth.[1] Depending upon the extent of hedgerow establishment, planting can be accomplished by hand, with a tractor-powered auger, or with a mechanical tree planter (Schoten 1988). A dibble or similar device may be used on sites that are inaccessible to mechanized planters. However, this method reduces planting rates by tenfold to approximately 500 seedlings per

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1 Personal Communication, 24 July 2001, Hollis H. Allen, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

individual per 8-hr day (Woehler and Dumke 1982). Hand planting of woody seedlings lends itself well to volunteer participation, such as scouting groups and conservation clubs, which can help defray labor costs.

Root systems must be kept moist throughout the planting operation, and holes must be excavated deep enough to accommodate the entire root system. Planting depth should be similar to that of the nursery beds. This depth can be determined by the root collar (a swelling at the base of the main stem where the root system separates), which marks the soil line of the nursery bed. Roots that are too long should be trimmed to the appropriate length and should never be permitted to "ball up" ("J-root") at the base of the hole to cause premature mortality. Schoten (1988) advised packing the soil around the planted tree to eliminate air pockets and then watering the plant immediately. Mulching conserves moisture and controls weeds. Therefore, establishing a circular mulch layer to a depth of 7 to 15 cm (3 to 6 in.) with a circumference extending 15 cm (6 in.) beyond the outer branch line will promote early establishment and rapid plant growth. Compaction of soil around the roots is paramount to seedling survival. Tillage methods used in site preparation trap air in the soil; therefore, the soil must be adequately compacted to prevent desiccation of seedling roots. Precipitation within 2 weeks after planting greatly enhances seedling survival (Woehler and Dumke 1982). If available, irrigation within 48 hr after planting is desirable.[1]

HEDGEROW MANAGEMENT

Vegetation Control. In the first few years, management consists primarily of protecting plantings from vegetative competition and animal depredation. Weed control around shrubs is particularly important during the first two years after planting (Woehler and Dumke 1982), since the presence of herbaceous vegetation is a major reason for plant mortality (Schoten 1988). Manual, mechanical, and/or chemical methods may be used and should be applied each year before seed production. The ground between rows of trees can be mowed or cultivated to control forbs and grasses (Schoten 1988). To prevent plant injury, machinery operators must avoid working too near individual plants; hand weeding may be required in the immediate vicinity of some plants. Properly applied mulches retard the growth of perennial forbs and eliminate many annuals, but mulching can add significantly to the cost of hedgerow maintenance in terms of manpower and materials. In some locales, materials such as sawdust or wood chips may be obtained at reasonable cost from sawmills, utility companies, and municipal or private tree maintenance companies. Mechanical weed control may not be needed if chemicals can achieve similar results. A number of pre- and post-emergent herbicides are available to effectively reduce herbaceous vegetation. Some herbicides are manufactured to control specific plants, while others control a broad array of species; therefore, the dominant forbs and grasses should be identified to select a herbicide that targets those species. Another effective procedure for eliminating weeds in the vicinity of planted vegetation is to use a plastic sheet interspersed with holes.[1] The sheet is cut so the target plant can be planted through it, and it is then stapled to the soil beside the plant. The plastic is porous enough to allow soil aeration and precipitation infiltration but will effectively prevent weeds from growing through it.

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Water. Many woody species commonly planted in hedgerows are adapted to arid environments and do not require a great deal of water to maintain vigor. However, a design emphasizing plant diversity will probably include several species that require a regular source of water for survival. Schoten (1988) recommended watering trees twice a week during establishment. Plants can be watered through a drip irrigation system, which requires only a small expenditure of time for periodic maintenance and provides an adequate supply of water to each plant. The system is economical, and waste is negligible because water drips slowly from each emittor, soaking a small area around the targeted plant.

Pruning and Renovation. Hedgerow trees and shrubs need periodic pruning. The end of the growing season is an appropriate time to inspect hedgerows and prune broken, disfigured, and diseased or infested branches (Schoten 1988). Straight trunks result in taller trees, which contribute to a more extensive protected zone behind the hedgerow, and are easier to develop if pruned while trees are young and susceptible to manipulation. Pruning one branch of a fork will prevent the formation of a weak point that may sustain damage during severe winds.

Hedgerow trees may eventually need to be thinned or removed in a release cutting. Trees may be killed in place to create snags for cavity nesters. Tops can be removed from conifers to prevent excessive heights. Topping is useful for stimulating lateral bud development and increasing the density of shrub canopy (Woehler and Dumke 1982). To preserve shrub stage integrity, tall tree species may be removed or topped during the dormant season upon reaching 3 m (10 ft) in height (Petrides 1942). As aging occurs, hedgerows will deteriorate and require renovation. Renovation includes thinning, removing dead and diseased trees or those species that did not adapt well, and adding new plants or rows where necessary. Severe pruning can rejuvenate some species as vigor declines (Woehler and Dumke 1982). Thinning should be conducted to maintain an approximate tree spacing of 7 m (23 ft) within rows, but closer spacing is permissible for shrubs and small hardwoods.

Wildlife Management. The management and maintenance practices described in the previous section were developed to maximize the health and longevity of hedgerows for the benefit of wildlife. Planting a variety of trees and shrubs will increase the structural diversity of vegetation and result in the creation of more habitat niches for wildlife (Yahner 1982, 1983a). Small food plots can be planted on the leeward sides of hedgerows to furnish additional wildlife food. To provide more sources of herbaceous food and cover, the edges of long, rectangular hedgerows can be maintained in forbs and grasses by lightly disking the outside perimeter to create the appropriate habitat conditions (Jackson 1969). Trees and shrubs that produce fruit crops in the fall and persist throughout the winter should be planted to enhance overwinter survival and improve the physiological condition of animals for the spring breeding season (Petrides 1942). To ensure mast production throughout the year, a hedgerow should contain at least one plant species that bears fruit each season. Trees and shrubs that produce soft, fleshy fruits readily attract wildlife and should be used whenever possible. Examples are American plum (*Prunus americana*), red mulberry (*Morus rubra*) (SCS 1980), and grapes (*Vitis* spp.) (Petrides 1942).

Tree species that can be planted to provide maximum benefits for avifauna include spruces (*Picea* spp.), pines (*Pinus* spp.), elms (*Ulmus* spp.), maples (*Acer* spp.), and ashes (*Fraxinus* spp.) (Yahner 1983a). Conifers provide cover and nesting habitat for avian species that prefer

dense cover, whereas hardwoods provide nesting sites for birds preferring open areas with better structural components. The seeds of conifers and fruits of hardwoods supply food for a number of birds. Planting grain between rows of a multi-rowed hedgerow can provide additional food (Jackson 1969, Burger and Oldenburg 1972, Morgan and Gates 1982, Warner and David 1982). To create superior wildlife habitat, the control of herbaceous vegetation and the use of insecticides and fungicides should be curtailed as hedgerows mature; chemicals should be applied only when insects or disease threaten young trees and shrubs. Trees that die should be left in place because of their value for insectivorous and cavity-nesting birds.

Evaluation. Since hedgerows deteriorate over time, habitat for a number of wildlife species can be expected to decline as well. Therefore, hedgerows should be evaluated periodically to monitor their health and assess their quality as wildlife habitat. Monitoring enables land managers to determine when habitat improvements are needed and to identify management actions that enhance habitat quality for wildlife. Since most wildlife species are attracted to plantings because of the available food and cover, it is necessary to monitor vegetative characteristics that reflect these habitat components. Measurements that provide data on plant cover, density, and species composition will usually suffice. For woody species in Minnesota shelterbelts, Yahner (1983a) measured tree and shrub density, cover, height, growth form diversity, and species diversity and richness. Variables for herbaceous species included plant diversity and richness, height, and growth form diversity.

Monitoring wildlife abundance over an extended period of time may enable the land manager to track the health of specific populations inhabiting windbreaks. Seasonal inventories yield the most data on hedgerow use but might not be feasible on certain project lands; in this case inventories should be conducted at least during the breeding season and winter months. Determining the presence or absence of individual species on a seasonal and annual basis might be suitable for hedgerow evaluations. For example, this technique could be used to examine annual turnover rates (Yahner 1983a).

Most mammal censuses have focused on small mammals because only smaller species restrict their daily activities to windbreak plantings. Since large mammals such as deer and elk have extensive home ranges, a census of hedgerows and fencerows alone would not provide reliable data. However, scent-stations can be effective in acquiring population indices for predators such as raccoons, foxes, and coyotes (Roughton and Sweeney 1978, Roughton 1979). This technique could provide much useful information in an extensive hedgerow program.

MANAGEMENT PROBLEMS: Most windbreaks experience periodic outbreaks of disease or episodes of animal damage. Diseases that affect vegetation can usually be treated successfully if symptoms are detected early; most animal damage is preventable and restricted to a few species. To minimize negative impacts, the manager should be aware of the more common diseases and the wildlife species that typically inflict damage on hedgerow plants.

Disease. Diseases that affect shelterbelt plantings can also affect trees and shrubs of hedgerows. Dutch elm disease seriously reduced Siberian (*Ulmus pumila*) and American elm (*U. americana*) in South Dakota shelterbelts (Barnes, Keyser, and Linder 1989), and Colorado blue spruce (*Picea pungens*) was highly susceptible to the Cytospera canker fungus in Minnesota

shelterbelts (Schoten 1988). Various aphids can cause much damage if not detected early. Schoten (1988) cautioned against planting Colorado blue spruce and Douglas fir (*Pseudotsuga menziesii*) in the same windbreak since these species serve as alternate hosts for the Cooley spruce gall aphid. Tatarian (*Lonicera tatarica*) honeysuckle and Zabel's (*L. morrowii* x *L. tatarica*) honeysuckle should be avoided because of potential damage also caused by an aphid (Schoten 1988). Cedar apple rust may infect windbreaks containing eastern red cedar (*Juniperus virginiana*), which serves as an alternate host for the fungus. Schoten (1988) warned that poplar species (*Populus* spp.) and hybrids are susceptible to a number of cankerous diseases that, once established, cannot be controlled. Flowering crab apple (*Malus* spp.) trees are susceptible to fire blight. Trees and shrubs require regular examination to detect disease in its initial stages, when eradication is easier to achieve.

Animal Damage. Rabbits, mice, and deer are responsible for most animal damage occurring in windbreaks. The impacts from depredation can be devastating in the early years of establishment, so it is advisable to periodically monitor for signs of damage and intervene as soon as possible. Repellants, physical barriers, and selective harvesting can be used to protect hedgerows during the first 2 to 3 years of existence.

Rabbits and mice were the dominant vertebrate pests in a South Dakota study (Barnes, Keyser, and Linder 1989). Most rabbit damage was sustained from late fall to early spring and varied with animal densities and locations. In Minnesota some species of woody vegetation were severely damaged by rabbits during winters of cyclic abundance (Schoten 1988). In South Dakota, rabbits displayed feeding preferences for specific trees and shrubs, preferring deciduous trees to deciduous shrubs and generally avoiding coniferous species (Barnes, Keyser, and Linder 1989). Eastern cottonwood (*Populus deltoides*) and red-osier dogwood (*Cornus stolonifera*) were the most highly preferred species, with 60 to 70 percent of the trees exhibiting rabbit damage. Most damage occurred to plants in the 1- and 2-year age classes. Damage from rabbit browsing began to decrease as trees reached 3 years of age, and plants showed no signs of damage by 5 to 10 years.

Various methods have been used to protect seedlings from browsing rabbits. Schoten (1988) described a photodegradable plastic sleeve that protected the plant when placed over a seedling and anchored to the ground. Individual hardware cloth exclosures (Schoten 1988) and sections of PVC plastic pipe (SCS 1980) have been successfully used but must eventually be removed to avoid restricting lateral growth. PVC pipe may also absorb enough solar radiation to induce heat-related stress in protected plants. Barnes, Keyser, and Linder (1989) recommended providing supplemental food sources that are more palatable to rabbits than woody browse and suggested placing old fruit or grain in windbreaks during winter and spring to entice rabbits away from trees and shrubs.

Mice are capable of girdling trees and shrubs (Schoten 1988). However, in South Dakota shelterbelts, mice were of secondary importance compared to rabbits, and rodent damage was negligible (Barnes, Keyser, and Linder 1989). Pocket gophers (*Thomomys bottae*) can inflict severe damage to both young and mature trees by destroying their root systems during spring and fall (Schoten 1988). Gopher damage is insidious because physical wounds are not apparent

on aboveground portions of woody plants. Symptoms include pale, dry, wilted foliage and plant inclination to one side.

Livestock and deer may also pose a threat to plantings. Jackson (1969) and Schoten (1988) recommended excluding livestock completely, because the effects of their browsing can severely disfigure plants and result in substantial plant mortality. Livestock compact the soil, which decreases water infiltration rates, and the nitrogen content of excreta can limit conifer growth (Schoten 1988). Deer occasionally injure certain plant species. Northern white cedar (*Thuja occidentalis*) is highly preferred browse, and some species, such as green ash (*Fraxinus pennsylvanica*), are sometimes used for antler rubbing (Schoten 1988). However, deer damage appears to be minor unless animals become concentrated in plantings for significant periods of time. For example, mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*) in Wyoming utilized a 49-ha (121-acre) commercial tree nursery as escape and thermal cover during a severe winter storm and consumed the needles of coniferous nursery stock, which resulted in extensive damage (Hammer 1989). Well-built fences established around the perimeter of windbreaks effectively exclude livestock but rarely exclude deer. Attaching repellent-soaked fabric to the tops of wooden stakes to establish a perimeter fence may discourage excessive deer use. Tree seedlings can be protected individually with hardware cloth exclosures similar to those used to discourage rabbits.

Exotic Species. Some woody plants widely used in windbreaks are exotic species. There is current concern that these species will escape cultivation, out-compete native species, and establish on sites formerly occupied by native vegetation. For example, Russian olive (*Eleagnus angustifolia*) was commonly planted in shelterbelts and became naturalized on riparian and moist-soil sites throughout the western states (Knopf and Olson 1984). It has displaced native riparian vegetation at many sites and dramatically impacted avian species composition. Insectivorous birds and cavity nesters experience the greatest negative impacts because Russian olive invasions usually result in monotypic stands lacking an abundance of snags and tree cavities (Olson and Knopf 1986a,b). Although Russian olive benefits birds that occupy tall-shrub vegetation and provides food and cover for farm wildlife (SCS 1980), any wildlife benefits derived from this species should be carefully weighed against its negative impacts on native flora and fauna (Olson and Knopf 1986b). Brush management techniques have been used to control Russian olive; cutting followed by burning or treating stumps with herbicide appears to be most effective.

Other introduced species, such as autumn olive, Tatarian honeysuckle, and Amur honeysuckle (*Lonicera maackii*) have also caused problems. Amur honeysuckle and common buckthorn (*Rhamnus cathartica*) provide a branch structure suitable for nest construction within the range of heights used by many songbird species (Whelan and Dilger 1992, 1995). Therefore, these shrubs may create a sink for nesting birds and cause increased predation within hedgerows. Schmidt and Whelan (1999) found that predation increased on birds nesting in exotic shrubs and highly recommended using native plants for the restoration of plant communities. Because of potential problems with nonindigenous species, it is recommended that only native trees and shrubs be used in hedgerows.

SUMMARY: Hedgerows and fencerows have been valuable additions to North American prairie landscapes for more than 100 years. These plantings not only protect agricultural interests from

climatic extremes but also provide important wildlife habitats. Although raptors, deer, and mammalian predators use hedgerows, birds and small mammals derive the greatest benefits from these plantings because of the increased vegetative complexity and structural diversity. Careful planning, management, maintenance, and renovation are necessary to ensure that hedgerows provide continual long-term protection and adequate wildlife habitat. Hedgerows should be designed to achieve construction objectives and to maximize their longevity and survival. Planting tree and shrub species adapted to the regional climate and site soil conditions will increase the probability of their survival for several decades. Proper inspection and management are crucial to successful establishment and persistence as protective barriers and wildlife habitat. A manager must be familiar with the insects, diseases, and wildlife species that can damage hedgerows and be able to recognize damage attributable to various pests. Carefully designed and maintained plantings should substantially improve the quality of wildlife habitat on the surrounding land. At Corps projects, especially in western and midwestern regions, hedgerows and fencerows can be effectively used to provide wildlife habitat in relatively open landscapes, to screen areas for privacy and containment of human activity, and to provide aesthetic appeal for recreational visitors.

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